BRC Copy

273

Memorandum

To: Stephanie Sibbet (Boeing)
Brian Mossman (Boeing)
Scott Zachary (Haley & Aldrich)

CC: Frank Lenzo

From: Jim Nguyen/Jeffrey Friedman JF

Date: 10/24/02

Re: Hydraulic Test Results – Former C-6 Facility

ARCADIS G&M (ARCADIS) has prepared this technical memorandum to summarize the results of the hydraulic test performed at the former Boeing C-6 facility located in Los Angeles, California. The test was conducted in accordance with the Hydraulic Test Memorandum submitted to Boeing on June 26, 2002.

The test was conducted in the Middle Bellflower Aquitard that extends to a depth of approximately 115 feet below ground surface (bgs) that consists of the B-Sand, the Middle Bellflower Mud (BFM), and the C-Sand. The test was conducted in the upper and lower layer of the B-Sand; referenced as the Upper and Lower B-Sand. The Upper B-Sand is composed primarily of silty sand, with the upper and lower contacts situated at approximately 65 feet to 75 feet below ground surface (bgs) (13 to 23 feet below Mean Sea Level (MSL)). The Lower B-Sand is composed primarily of sand to gravelly sand with the upper and lower contact situated at approximately 75 feet to 90 feet bgs (23 to 38 feet below MSL). The hydraulic test was conducted inside the source area of Building 2, within the area identified to contain groundwater impacted by Trichloroethene (TCE) above 10,000 micrograms per liter (μg/L). Please refer to Figures 1 and 2 for the location of the hydraulic test.

Summarized below are the objectives, well installation activities, test procedures, and results.

Objectives

The purpose of the hydraulic test is to collect data to determine the following:

1. The hydraulic conductivity (K value) in the Upper and Lower B-Sand. The K value were evaluated using the slug test data;
2. The radius of influence for the amendment points in each zone (evaluated by injection of potable water with a bromide tracer);
3. The effectiveness of using a ¾-inch diameter casing amendment point, installed using a cone penetrometer testing (CPT) rig. The effectiveness of using a ¾-inch diameter casing amendment point, installed using a cone penetrometer testing (CPT) rig. The effectiveness is defined as how easily the amendment point can be installed, the integrity of the well, how well the solution is distributed to the targeted zones, and the duration of delivery; and

4. Dilution effects of groundwater on the amendment solution.

Well Installation and Development

One hydraulic test point (HT-0001), two down gradient monitoring points (HT-0003 and MW-0001), and one cross gradient monitoring point (HT-0002) were installed on June 25, 26, and 27, 2002 (Figure 2). Each location was completed with dual-nested points for a total of eight discreet well screen intervals. The points were screened between 65 and 75 feet below bgs (targeting the Upper B Sand and designated with an "A" suffix following the well number), and between 80 and 90 feet bgs (targeting the Lower B Sand and designated with an "B" suffix). Construction boring logs are included as Appendix A. In addition, CPT logging was conducted at HT-0001. The CPT log is included in Appendix B.

The hydraulic test points HT-0001 was completed with 0.75-inch diameter casings using a CPT rig. The downgradient and crossgradient points HT-0002 and HT-003 were completed using 1.5-inch diameter casings using a hollow-stem auger (HSA) drill rig. The monitoring point MW-0001 was completed using 2-inch diameter PVC casings using a HSA drill rig. Following well installation, monitoring points HT-0002, HT-0003, and MW-0001 were developed on July 1, 2002. Point HT-0001 was not developed due to the small diameter of the casing.

Slug Test Procedures and Results

After the wells were installed and developed, slug tests were conducted on July 11, 2002. Rising head slug tests were conducted using well MW-0001A (screened in the Upper B-Sand) and MW-0001B (screened in the Lower B-Sand). The rising head test was conducted by removing a slug from the well and recording the rate at which the water rises to static level. The rate at which water flows into the well and returns to the static level is used to estimate the hydraulic conductivity of the water-bearing zone.

To remove a slug of water from MW-0001A and MW-0001B, a PVC pipe (commonly referred to as a stinger) was lowered down to the groundwater. The stinger was connected to a hose that was connected to a vacuum truck. A vacuum was then applied to the hose to remove a slug of water from the well. The volume removed from wells MW-0001A and MW-0001B was approximately 5 and 15 gallons, respectively. A pressure transducer was placed approximately one foot above the bottom of the well to record the changes in the water level before a slug was removed and as groundwater rises to static level. The pressure transducers/data logger used for the test was In-Situ Troll (MiniTroll Pro, Model 8572). The data collected by the Troll were up-loaded into a laptop field computer. The test was considered complete once the groundwater level returned to the original static groundwater level. Data collected from the Trolls are included in Appendix C.

Due to the composition of the Lower B-Sand (sand and gravely sand), instantaneous recharge was observed and, therefore, produced no significant drawdown in the well screen. Due to the quick recharge of the Lower B-Sand, no data could be collected to estimate the hydraulic conductivity. Conversely, due to the composition of the Upper B-Sand (silty sand), drawdown was observed in MW-0001A.

The data obtained from the Upper B-Sand was analyzed using hydraulic evaluation program called Aqtesolv (Copyright © HydroSOLVE, Inc.). The software permits time drawdown data to be evaluated using two commonly used slug test evaluation methodologies called the Bower-Rice and Hvorslev methods. The results of the analysis are summarized in the table provided on page 3. The hydraulic conductivity estimated from the Bouwer-Rice and Hvorslev methods yielded 3.87 x 10^{-}

^{2}cenitmeters/second (cm/sec) and 2.44 x 10^{-2} cm/sec, respectively. The estimated hydraulic conductivity is higher than expected for a silty sand zone. Based on Freeze and Cherry[1], the hydraulic conductivity for a silty sand zone should be approximately in the range of 1 X 10^{-3} to 1 x 10^{-5}. It is hypothesized that the difference between the slug test results and the published hydraulic conductivity were likely influenced by the sand pack situated around the well screen, thus, producing higher than expected K-values. Therefore, ARCADIS elected to rerun Aqtesolv using the data collected later in the test (i.e., the draw down data obtained after the break in slope, see chart in Appendix C). It is assumed that the early drawdown data is most likely representing recharge from the surrounding sand pack, and the later drawdown data is recharge from the formation. The calculated hydraulic conductivities based on the tail-end data set using the Bower-Rice and Hvorslev methods indicate K-values ranging from 3.67 x 10^{-3} to 5.77 x 10^{-3} cm/sec, which is more representative of a water bearing material, composed of silty sand. Using an averaged site hydraulic gradient of 0.0014 (Haley & Aldrich, Inc., 2002[2]) and a porosity of 0.31, the groundwater velocity was estimated to be between 17 and 27 feet per year using the Bouwer-Rice and Hvorslev methods, respectively. The slug test analysis using the Bouwer-Rice and Hvorslev methods are included in Appendices D through G.

Typical assumptions used in the Bouwer-Rice and Hvorslev methods are summarized below:

1. Homogeneous isotropic aquifer with infinite amount of water.
2. Exterior boundary of the aquifer is not encountered and therefore the aquifer is of infinite extent (Domenico & Schwartz, 1997).
3. The well has infinitesimal diameter compared with the aquifer.
4. The slab block is equivalent to the total depth of the well. Thus, the well completely penetrates the aquifer and, the aquifer depth is the same as the well depth.
5. Depth of saturated part of the aquifer is equivalent to the depth of water in the well.
6. The well is located in an unconfined aquifer.
7. Maximum possible iterations (999) were performed to lessen the standard errors in the result and obtain a best-fit curve.

Table 1: Estimated Hydraulic Conductivity (using well MW-0001A)

Analysis		**Hydraulic conductivity (cm/sec)**	**Hydraulic gradient (ft/ft)**	**Porosity**	**Groundwater Velocity**	
Method	**Data Set**				**(ft/day)**	**(ft/yr)**
Hvorslev	Complete	3.87 x 10^{-2}	0.0014	0.31	0.50	181
Bouwer-Rice	Complete	2.44 x 10^{-2}	0.0014	0.31	0.31	114
Hvorslev	Partial	5.77 x 10^{-3}	0.0014	0.31	0.07	27
Bouwer-Rice	Partial	3.67 x10^{-3}	0.0014	0.31	0.05	17

[1] Freeze and Cherry, "Groundwater", 1979, Table 2-1.
[2] Annual Groundwater Monitoring Report, 2002, Haley & Aldrich, Inc

Injection Test Procedures and Results

The injection test was conducted on July 31, 2002. Testing was conducted in the Upper and Lower B-Sand using HT-0001A, HT-0001B, and MW-0001A. Potable water was added to each zone at varying pressures. Pressure transducers were installed in adjacent monitoring points to evaluate changes in groundwater elevation during injection activities.

The first test was conducted using HT-0001B as the injection point. A maximum pressure of 5 pounds per square inch (psi) was used to inject a total of 400 gallons over a duration of approximately 39 minutes. A flow rate of approximately 10 gallons per minute (gpm) was achieved during this test. A 0.4 to 1 foot change in groundwater elevation was noted in three adjacent monitoring wells (the furthest well is located approximately 15 feet from HT-0001B). A plot showing changes in groundwater elevations are included in Appendix H.

A second test was conducted using HT-0001A as the injection point. Potable water was initially injected at a pressure of 5 psi. A total of 3 gpm was achieved. The pressure was increased to 10 psi. Approximately 50 gallons was injected into the well before water was observed escaping around the well casing at land surface; migrating from the subsurface. It was suspected that the well might not have formed a proper seal during well construction; however, a change in groundwater elevation was noted in the nearby monitoring wells (0.4 ft maximum) during this injection event. Well HT-0001A was reinstalled on August 6, 2002.

Due to the results from the second test, a third test was conducted using well MW-0001A. Very little pressure (<1 psi) was required to inject 423 gallons of water over a duration of approximately 26 minutes. A flow rate of approximately 16 gpm was achieved during this test. Change in groundwater elevation was noted in the adjacent monitoring wells ranging from 0.8 to 1.6 feet (Appendix H). The table below summarizes the results of the injection tests.

Table 2: Results from Injection Test

Test No.	Injection Test Well	Formation	Soil Type	Well Screen (ft bgs)	Injection Pressure (psi)	Injection Flow Rate (gpm)	Change in Groundwater Elevation from Monitoring Wells (ft)
1	HT-0001B	Lower B-Sand	Sand to gravelly sand	80-90	5	10.3	0.4 to 1
2	HT-0001A	Upper B-Sand	Silty sand	65-75	10	3	0.4
3	MW-0001A	Upper B-Sand	Silty sand	65-75	<1	16	0.8 to 1.6

Bromide Tracer Test Procedures and Results

The bromide tracer test will be conducted once the Waste Discharge Requirement (WDR) permit is granted from the Los Angeles Regional Water Quality Control Board. Results from the bromide tracer test will be submitted under a separate cover.

Conclusion

Based on the results of the hydraulic test, the following conclusions can be made:

1. The estimated hydraulic conductivity for the Upper B-Sand is between 3.67×10^{-3} to 5.77×10^{-3} cm/sec. The estimated groundwater velocity using these values is between 17 and 27 feet per year. Due to the composition of the Lower B-Sand (sand and gravely sand) a slug test was not successful at obtaining data to estimate the hydraulic conductivity.
2. A CPT rig was successful at installing the ¾-inch diameter casing amendment point (HT-0001) to a depth of 90 feet bgs. The CPT rig was able to push a steel casing to 90 feet bgs in approximately 17 minutes. The ¾-inch diameter well was used to inject water with a flow rate of approximately 10 gpm, and generated influence (via change in groundwater elevation) from monitoring wells located 15 feet from the injection well. However, careful backfilling of the well will be required to provide a proper seal.

Figures:
1-Hydraulic Test Location
2-Hydraulic Test Layout

Appendices:
A – Well Construction Log
B – Cone Penetrometer Test Data
C – Slug Test Data From Minitroll
D – Slug Test Analysis (Bouwer-Rice Method) for MW-0001A Using Complete Data Set
E – Slug Test Analysis (Hvorslev Method) for MW-0001A Using Complete Data Set
F – Slug Test Analysis (Bouwer-Rice Method) for MW-0001A Using Partial Data Set
G – Slug Test Analysis (Hvorslev Method) for MW-0001A Using Partial Data Set
H – Change in Groundwater Elevation During Injection Activities